MULTIPLE REFLECTIVITY BAND REFLECTOR FOR LASER WAVELENGTH MONITORING

CLAIMS

What is claimed is:

1. A monitored laser system, comprising:

a laser comprising

a first mirror,

an exit mirror,

at least a portion of a laser cavity defined by the first mirror and the exit mirror; and

an active region located in the laser cavity, the active region containing a material that is capable of stimulated emission at one or more wavelengths of laser light;

a multiple reflectivity band reflector (MRBR) coupled to at least a portion of laser light emitted from the laser and transmitting filtered laser light, the MRBR having at least first and second wavelength bands with reflectivity above a particular reflectivity separated by at least a third wavelength band having reflectivity below the particular reflectivity;

a first photodiode coupled to at least a portion of the filtered laser light and producing an output based on the amount and wavelength of light received; and

means for adjusting the emitted wavelength of the laser toward a particular wavelength in one of the at least first, second, and third wavelength bands based at least in part on the output of the first photodiode.

2. The monitored laser system of claim 1, wherein the particular wavelength is in the 1500-1600 nm range.

3. The monitored laser system of claim 1, further comprising a power source coupled to the active region, wherein the means for adjusting the emitted wavelength includes a power source control.

4. The monitored laser system of claim 1, wherein the means for adjusting the emitted wavelength includes a means for adjusting the temperature of the laser.

5. The monitored laser system of claim 1, wherein the first mirror includes a plurality of layers and the means for adjusting the emitted wavelength modifies the refractive index of at least one of the layers.

6. The monitored laser system of claim 1, wherein the portion of the laser light coupled to the MRBR is transmitted through the first mirror.

7. The monitored laser system of claim 1, wherein the portion of the laser light coupled to the MRBR is transmitted through the exit mirror.

8. The monitored laser system of claim 7, further comprising an optical tap having at least a first input and first and second outputs and wherein a portion of the laser light is coupled to the first input and the MRBR is coupled to the first output.

9. The monitored laser system of claim 1, further comprising a second mirror and wherein the laser cavity is a two-section laser cavity defined by the first mirror, the exit mirror, and the second mirror.

10. The monitored laser system of claim 1, further comprising

a second photodiode coupled to at least a portion of the laser light and producing an output based on the amount and wavelength of light received; and wherein the means for adjusting the emitted wavelength of the laser toward a particular wavelength in one of the at least first, second, and third wavelength bands is based at least in part on both the output of the first photodiode and the output of the second photodiode.

11. The monitored laser system of claim 1, wherein the MRBR has at least six wavelength

bands with reflectivity above the particular reflectivity with at least one wavelength band with reflectivity below the particular reflectivity separating each sequential pair of the at least six wavelength bands.

12. The monitored laser system of claim 11, wherein the six wavelength bands are within the range of 1500-1600 nm.

13. The monitored laser system of claim 12, wherein the MRBR includes at least 60 material layers.

14. The monitored laser system of claim 13, wherein the MRBR material layers include Al_2O_3 layers, TiO_2 layers, and SiO_2 layers.

15. The layer system of claim 14, wherein the MRBR material layers are based on the layer formula $EABCD(ABC)^{60}ABCD(ABC)^{60}AB$ with the layer identifiers corresponding to the following:

A representing Al_2O_3, B representing TiO_2, C representing SiO_2, D representing Si, and E representing Al, with layers A-D having substantially the same thickness after adjustment for refractive index.

16. The monitored laser system of claim 1, wherein the MRBR has at least thirteen wavelength bands with reflectivity above the particular reflectivity with at least one wavelength band with reflectivity below the particular reflectivity separating each sequential pair of the at least thirteen wavelength bands.

17. The monitored laser system of claim 16, wherein the thirteen wavelength bands are within the range of 1500-1600 nm.

18. The monitored laser system of claim 17, wherein the MRBR has layers based on the layer formula $ABC(ABCD)^2(ABDC)^{68}(ABCD)$ with the layer identifiers corresponding to the following:

A representing Al_2O_3, B representing TiO_2, C representing SiO_2, and D representing Si, with layers A-C having substantially the same thickness after adjustment for refractive index and layer D having a thickness substantially 1/0.75 times that of layer A after adjustment for refractive index.

19. The monitored laser system of claim 1, wherein the first and second wavelength bands include wavelengths specified in the ITU grid.

20. The monitored laser system of claim 1, wherein the first reflectivity band includes a peak wavelength and the particular wavelength is equal to the peak wavelength.

21. The monitored laser system of claim 1, wherein the third reflectivity band includes a trough wavelength and the particular wavelength is equal to the trough wavelength.

22. A method for monitoring a laser system comprising the steps of:

pumping an active region located in a laser cavity of a laser, at least a portion of the laser cavity defined by a first mirror and an exit mirror, until laser light is emitted;

coupling a multiple reflectivity band reflector (MRBR) to at least a portion of the emitted laser light, the MRBR having at least first and second wavelength bands with reflectivity above a particular reflectivity separated by at least a third wavelength band having reflectivity below the particular reflectivity, such that the MRBR transmits filtered laser light;

coupling at least a portion of the filtered laser light to a first photodiode such that an output is produced based on the amount and wavelength of light received by the first photodiode; and

adjusting the emitted wavelength of the laser toward a desired wavelength in one of the at least first, second, and third wavelength bands based at least in part on the output of the first photodiode.

23. The method of claim 22, wherein the step of adjusting the emitted wavelength of the laser

includes modifying the degree of pumping the active region.

24. The method of claim 22, wherein the step of adjusting the emitted wavelength of the laser includes adjusting the temperature of the laser.

25. The method of claim 22, wherein the first mirror includes a plurality of layers and the step of adjusting the emitted wavelength of the laser includes modifying the refractive index of at least one of the layers.

26. The method of claim 22, further comprising the step of coupling at least a portion of the emitted laser light to a second photodiode such that an output is produced based on the amount and wavelength of light received by the second photodiode; and wherein the step of adjusting the emitted wavelength of the laser includes adjusting based at least in part on the output of both the first and second photodiodes.

27. The method of claim 22, wherein the step of adjusting the emitted wavelength of the laser includes measuring an initial output of the first photodiode, modifying a tuning value by a positive step, measuring a new output of the first photodiode, and comparing the new output to the initial output.

28. The method of claim 27, wherein the step of adjusting the emitted wavelength of the laser includes modifying the tuning value by a negative step.

29. A computer program, stored on a tangible storage medium, for monitoring a laser, the program comprising executable instructions that cause a processor to

send a signal resulting in pumping an active region located in a laser cavity of a laser, at least a portion of the laser cavity defined by a first mirror and an exit mirror, until laser light is emitted;

store an output of a first photodiode coupled to at least a portion of filtered laser light transmitted by an MRBR that is coupled to at least a portion of the laser light; and

send a signal resulting in adjusting the emitted wavelength of the laser toward a desired wavelength based at least in part on the stored output of the first photodiode.

30. The computer program of claim 29, wherein the executable instructions that cause the processor to send a signal resulting in adjusting the emitted wavelength of the laser toward a desired wavelength based at least in part on the stored output of the first photodiode include executable instructions that cause a computer to:

store an initial output of the first photodiode,

send a signal resulting in modifying a tuning value by a positive step,

store a new output of the first photodiode, and

compare the new output to the initial output.

31. The computer program of claim 30, wherein the executable instructions that cause the processor to send a signal resulting in adjusting the emitted wavelength of the laser toward a desired wavelength based at least in part on the stored output of the first photodiode include executable instructions that cause a computer to send a signal resulting in modifying a tuning value by a negative step.

32. The computer program of claim 29, further comprising executable instructions that cause a computer to store an output of a second photodiode coupled to at least a portion the laser light and wherein the executable instructions that cause the processor to send a signal resulting in adjusting the emitted wavelength of the laser toward a desired wavelength based at least in part on the stored output of the first photodiode include executable instructions that cause a computer to send a signal resulting in adjusting the emitted wavelength of the laser toward a desired wavelength based at least in part on the stored output of the second photodiode.

33. A multiple reflectivity band reflector, comprising a plurality of layers of material arranged in parallel such that the reflector has:

a first wavelength band with reflectivity above a lasing threshold reflectivity;

a second wavelength band with reflectivity above the lasing threshold reflectivity; and

a third wavelength band including wavelengths between the first and second wavelength bands having reflectivity below the lasing threshold reflectivity.

34. A laser apparatus, comprising:

a laser comprising:

a first mirror;

a second mirror comprising a multiple reflectivity band reflector (MRBR) having at least first and second wavelength bands with reflectivity above a lasing threshold reflectivity separated by a third wavelength band having reflectivity below the lasing threshold reflectivity;

at least a portion of a laser cavity defined by the first mirror and the MRBR; and

an active region located within the laser cavity, the active region containing a material that is capable of stimulated emission at one or more wavelengths in the first and second wavelength bands.

35. A method for tuning a laser comprising the steps of:

pumping an active region located in a laser cavity of the laser with pumping energy to cause the active region to generate laser light, at least a portion of said laser cavity defined by a first mirror and a second mirror comprising a multiple reflectivity band reflector (MRBR), said MRBR having at least first and second wavelength bands with reflectivity above a lasing threshold reflectivity separated by a third wavelength band having reflectivity below the lasing threshold reflectivity; and

adjusting the gain spectrum of the laser simultaneously with the step of pumping the active region to select one of the at least first and second wavelength bands, thereby providing for lasing by the laser at a wavelength within said selected one of said wavelength bands.

36. A multiple reflectivity band reflector comprising a plurality of layers of material arranged in parallel such that the reflector has a plurality of reflectivity peaks within a wavelength range of interest, each reflectivity peak separated from neighboring reflectivity peak by a reflectivity trough

having a trough minimum, said reflectivity peaks characterized by a peak profile and said trough minima between said reflectivity peaks characterized by a trough profile, wherein at least one of said peak profile and said trough profile has a substantially non-constant relationship of wavelength to reflectivity.

37. A monitored laser system, comprising:

a laser comprising

a first mirror,

an exit mirror,

at least a portion of a laser cavity defined by the first mirror and the exit mirror; and

an active region located in the laser cavity, the active region containing a material that is capable of stimulated emission at one or more wavelengths of laser light within a tuning range of the laser;

a multiple reflectivity band reflector (MRBR) coupled to at least a portion of laser light emitted from the laser and transmitting filtered laser light, the MRBR comprising a plurality of layers of material arranged in parallel such that the reflector has a plurality of reflectivity peaks within the tuning range, each reflectivity peak separated from neighboring reflectivity peak by a reflectivity trough having a trough minimum, said reflectivity peaks characterized by a peak profile and said trough minima between said reflectivity peaks characterized by a trough profile, wherein at least one of said peak profile and said trough profile has a substantially non-constant relationship of wavelength to reflectivity;

a first photodiode coupled to at least a portion of the filtered laser light and producing an output based on the amount of light received; and

means for adjusting the emitted wavelength of the laser toward a desired wavelength within the tuning range based at least in part on the output of the first photodiode.

38. A multiple reflectivity band reflector comprising a first reflector and a second reflector arranged in parallel and separated by a distance, wherein at least one of the first and second reflectors varies in reflectance over a wavelength range of interest, so that the reflector has a

plurality of reflectivity peaks within the wavelength range of interest, each reflectivity peak separated from neighboring reflectivity peak by a reflectivity trough having a trough minimum, said reflectivity peaks characterized by a peak profile and said trough minima between said reflectivity peaks characterized by a trough profile, wherein at least one of said peak profile and said trough profile has a substantially non-constant relationship of wavelength to reflectivity.

39. An apparatus for laser wavelength monitoring, comprising a laser, a multiple reflectivity band reflector for filtering laser light, a monitoring photodiode for receiving the filtered laser light, and a means for locking the laser wavelength onto a target wavelength in accordance with the signal received by the monitoring photodiode.

40. A monitored laser system, comprising:

a laser comprising

a first mirror,

an exit mirror,

at least a portion of a laser cavity defined by the first mirror and the exit mirror; and

an active region located in the laser cavity, the active region containing a material that is capable of stimulated emission at one or more wavelengths such that laser light is emitted from the laser;

a multiple reflectivity band reflector (MRBR) coupled to at least a portion of the emitted laser light and transmitting filtered laser light, the MRBR having at least first and second wavelength bands with reflectivity above a particular reflectivity separated by at least a third wavelength band having reflectivity below the particular reflectivity;

a first photodiode coupled to at least a portion of the filtered laser light and producing an output based on the amount and wavelength of light received; and

a non-section-112(6) means for adjusting the emitted wavelength of the laser toward a particular wavelength in one of the at least first, second, and third wavelength bands based at least in part on the output of the first photodiode.